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Emergency Vibration Horn – Alternative Solution for Emergency Vehicular Horn using Iot

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ABSTRACT

In modern urban environments, emergency vehicles such as ambulances, fire trucks, and police vehicles face significant challenges when navigating through congested traffic. The conventional audio-based horn systems often fail to alert nearby vehicles effectively, particularly in noisy conditions or for hearing-impaired drivers. This research introduces an IoT-based Emergency Vibration Horn system that supplements or replaces traditional horns with a real-time, non-auditory vibration alert mechanism. By leveraging wireless communication through HC-12 modules and microcontroller-based control using Arduino Uno, the system transmits alerts from emergency vehicles to surrounding vehicles equipped with receivers and vibration motors. This tactile feedback ensures immediate awareness, facilitating quicker path clearance for emergency response units. The system is designed to be low-cost, scalable, and highly effective, enhancing emergency vehicle efficiency and reducing response time in critical situations.

Keywords—IoT, Arduino, Vibration Motor, HC-12, Wireless Communication, Led Screen, Silent Horn, Noise Pollution

INTRODUCTION

Emergency vehicles are critical to public safety, tasked with responding rapidly to life-threatening situations such as medical emergencies, fires, accidents, and criminal activities. In such cases, seconds can determine the outcome between life and death. However, emergency responders often face delays in reaching their destinations due to heavy traffic congestion, inattentive drivers, or physical roadblocks. Even though sirens and traditional horns are used to alert drivers, their effectiveness is severely compromised in urban areas filled with background noise from vehicles, construction, and public activities. Furthermore, some drivers may suffer from hearing loss or may be distracted, making them less responsive to sound-based alerts.

To address these concerns, this research proposes an advanced vehicular alert system based on the Internet of Things (IoT). Unlike conventional methods, the Emergency Vibration Horn system provides real-time, wireless, tactile alerts to nearby vehicles, enabling drivers to recognize and respond promptly to approaching emergency services. This system is not only inclusive for the hearing-impaired but also ensures reliable alerts in noisy conditions. With the rising demand for smarter transportation infrastructure, implementing a complementary and efficient alert system can significantly enhance emergency vehicle mobility and overall traffic management.

The emergence of the Internet of Things (IoT) offers promising solutions to modern-day communication challenges by enabling smart and context-aware interactions between devices. This research proposes an IoT-based vibration alert system as a silent alternative to conventional vehicle horns. The system utilizes Arduino Uno microcontrollers, HC-12 wireless RF modules, and vibration motors to establish a wireless, non-auditory communication link between two vehicles. When a driver presses a button on the sender unit, a wireless signal is transmitted, and the receiver unit responds by activating a vibration motor—alerting the other driver through tactile feedback rather than sound.

The proposed system is designed to be cost-effective, user-friendly, and highly beneficial for scenarios where sound-based alerts are either discouraged or ineffective. In addition to reducing environmental noise, it holds significant value in improving road safety and enhancing communication for differently-abled individuals. This research aims to demonstrate the feasibility and effectiveness of implementing vibration-based vehicle alert systems as a step toward smarter, quieter, and more inclusive transportation networks.

LITERATURE REVIEW

Noise pollution caused by vehicular horns has been a topic of increasing concern in recent years. According to the World Health Organization (WHO), exposure to excessive noise can lead to numerous health issues including hypertension, stress, hearing impairment, and sleep disturbances. In response, researchers have explored alternative methods of non-verbal communication between vehicles to reduce dependence on sound-based alerts.

Previous studies have investigated the use of smart communication systems in vehicles, particularly using Internet of Things (IoT) and wireless sensor networks (WSNs). A study published in the International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE, 2019) discussed integrating ultrasonic sensors and GSM modules for vehicle alert systems but focused primarily on collision avoidance rather than horn alternatives. Another related innovation was proposed by Roy et al. (AJER, 2016), who explored tactile interfaces for deaf and hard-of-hearing drivers, emphasizing the importance of non-auditory sensory feedback for safe driving.

While most existing research emphasizes safety through object detection, GPS, or automatic braking systems, very few have addressed the issue of noise pollution due to honking. Some commercial attempts such as the use of visual signals (flashing lights) were limited by their visibility constraints in daylight and their inefficiency in heavy traffic conditions.
The use of vibration motors, typically found in smartphones and wearable technology, offers a promising alternative for tactile feedback. Combined with Arduino-based wireless communication systems like HC-12, it becomes feasible to design a simple yet efficient vehicleto-vehicle signalingsystem. These technologies have previously been used in assistive tech for visually or hearing-impaired users, but their integration into vehicles for replacing horns remains underexplored.

Therefore, this research fills a critical gap by proposing a silent, vibration-based alert system that leverages cost-effective hardware components and open-source programming tools. By addressing both the environmental and inclusivity aspects of transportation, the proposed solution contributes toward more sustainable and accessible vehicular communication systems.

METHODOLOGY

The implementation of the Emergency Vibration Horn system followed a systematic approach that included hardware configuration, software development, circuit testing, and performance evaluation. The initial phase involved the selection and procurement of essential hardware components such as Arduino Uno boards, HC-12 wireless modules, push buttons, and vibration motors. Each component was carefully tested individually before being integrated into the sender and receiver units.

Circuit diagrams were designed to outline the connection logic for both units. In the sender module, a push button was connected to a digital input pin on the Arduino Uno. When pressed, the Arduino sends a signal using the HC-12 RF transmitter. On the receiving end, the receiver's Arduino is programmed to constantly monitor incoming serial data from the HC-12 module. If the received message matches the predefined alert string, the Arduino triggers a digital output pin that activates the vibration motor.

The software code was written in embedded C/C++ using the Arduino IDE. The logic included serial communication protocols, condition-based signal comparison, and timed motor activation. After code development, the prototype was assembled on a breadboard for testing.

During testing, different scenarios were simulated, including short-range and long-range communication, signal consistency under movement, and system responsiveness to repeated button presses. Adjustments were made to optimize signal delay, motor activation time, and power efficiency. Once the prototype demonstrated consistent and reliable performance, it was validated for range, latency, and real-time feedback, confirming its effectiveness as an emergency alert system for vehicular use.

Objectives

The central objective of this research is to develop a reliable, efficient, and inclusive alternative to traditional emergency vehicle horn systems using Internet of Things (IoT) technologies. The project aims to address the inefficiencies observed in existing auditory-based warning mechanisms by offering a supplementary vibration-based alert system.

This system is designed to function in real time, improving the responsiveness of civilian drivers to the presence of emergency vehicles, thereby allowing faster and safer navigation through traffic. Another goal is to provide an innovative solution that can accommodate hearing-impaired individuals who may not respond to typical sound-based warnings. By making the system cost-effective, easy to deploy, and compatible with existing infrastructure, it becomes more viable for large-scale implementation.

The system further promotes the broader concept of smart traffic management, helping to integrate modern technology into transportation systems to enhance road safety and emergency service delivery.

Components Used

The successful implementation of the Emergency Vibration Horn system relies on a combination of hardware components and programming tools that work together to enable real-time wireless communication and feedback. At the heart of the system are two Arduino Uno microcontrollers—one installed in the emergency vehicle and the other in a regular vehicle. The Arduino Uno is chosen due to its compatibility with open-source software, ease of programming, and sufficient digital I/O pins for handling the input/output operations of the project. Each unit includes an HC-12 RF module to facilitate long-range, low-power wireless communication between the vehicles.

Fig - Hc-12

To trigger the alert, the emergency vehicle is equipped with a push button that, when pressed, sends a signal through the HC-12 module to any nearby receivers. Upon receiving the signal, the receiver's microcontroller processes it and activates a compact vibration motor installed inside the vehicle cabin.

This motor generates a noticeable tactile feedback, prompting the driver to yield. In addition, the setup involves the use of breadboards for prototyping, jumper wires for interconnections, resistors for electrical protection, and USB cables for power and programming. The software development is handled using the Arduino IDE, a lightweight platform used to compile and upload the embedded C/C++ code that governs the system's behavior.

Fig-Vibration Motor

This integration of both hardware and software forms the backbone of the Emergency Vibration Horn system, enabling it to function effectively in diverse urban scenarios. Each component has been carefully selected for its balance of cost, performance, and compatibility with the overall design goals of the project.

Fig-Arduino Uno

Software and Programming Tools

Tool / Language	Purpose
Arduino IDE	Used for writing, compiling, and uploading code to the Arduino boards
C / C++ (Arduino Language)	Programming logic for button press detection, signal transmission, and vibration triggering
HC-12 Serial Communication (AT Commands)	Manages wireless communication configuration between modules
Embedded C Concepts	Handling digital I/O operations such as digitalRead(), digitalWrite(), delay(), etc.
Operating System (Windows/Linux)	Platform used to run the Arduino IDE and program the devices

System Overview

The proposed IoT-based vibration alert system is designed to enable silent communication between two vehicles using wireless technology. The system is divided into two major functional blocks: the Sender Unit and the Receiver Unit. Each of these units is powered by an Arduino Uno microcontroller and communicates wirelessly using the HC-12 RF module. The Sender Unit is installed in the emergency vehicle and features a push button that is directly connected to the Arduino Uno. When the driver presses this button, it triggers the Arduino to transmit a predefined signal—typically

the string "ALERT"—through the HC-12 wireless module. This alert signal is broadcasted to the surrounding vehicles within communication range.

On the receiving end, the Receiver Unit is integrated into the target or civilian vehicle. It contains another Arduino Uno microcontroller paired with an HC-12 receiver module. This unit constantly listens for incoming signals. Once the predefined "ALERT" string is received and verified, the Arduino activates a vibration motor embedded in the dashboard or driver area. The vibration motor serves as a silent notification mechanism to alert the driver about the approaching emergency vehicle.

Working Principle

The system begins its operation when the emergency vehicle driver presses the push button connected to the Sender Unit. The Arduino continuously monitors the state of this button using digital input functions. Upon detecting a press, it initiates a wireless transmission of the string "ALERT" through the HC-12 RF module, utilizing UART-based serial communication.

This signal is picked up by the HC-12 module of the Receiver Unit. The receiver's Arduino then reads the incoming data stream and compares the message against the expected "ALERT" keyword. If the match is successful, the system activates a vibration motor by sending a high digital signal to the motor's control pin. This motor remains active for a short duration, long enough to alert the driver without causing unnecessary distraction or annoyance.

Once the signal is no longer received, or a predefined timeout occurs, the Arduino resets the motor control pin, turning the vibration off and returning the system to its idle listening state. This ensures energy efficiency and avoids continuous activation in case of repeated or prolonged signals.

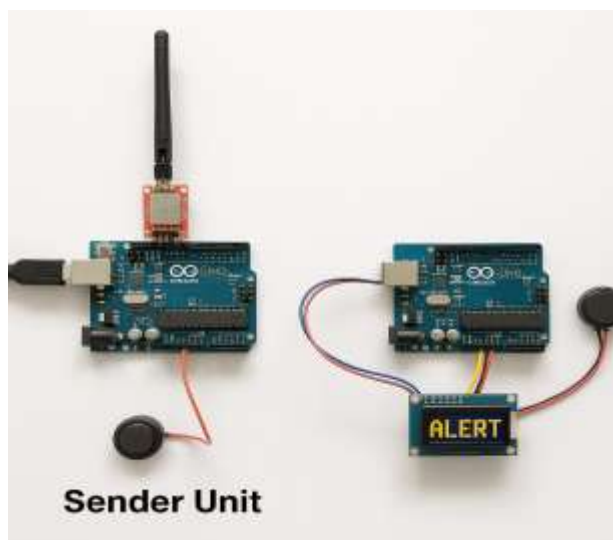
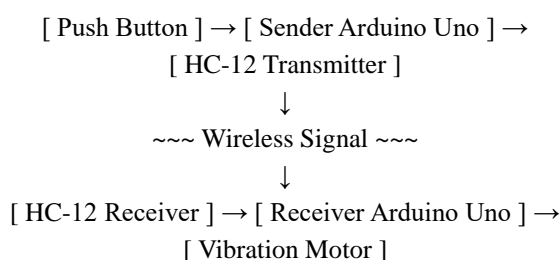



Fig- Project Model

Block Diagram

[Push Button] → [Sender Arduino Uno] →
[HC-12 Transmitter]
↓
~~~ Wireless Signal ~~~
↓
[HC-12 Receiver] → [Receiver Arduino Uno] →
[Vibration Motor]
~~~

Advantages

The Emergency Vibration Horn system provides key benefits that address the shortcomings of traditional sound-based emergency alerts. It delivers non-auditory communication through vibration, making it effective in noisy environments or for distracted drivers. This tactile feedback ensures alerts are received promptly, even when sirens or horns are less noticeable.

The system also supports inclusivity by assisting hearing-impaired drivers who may not respond to typical audio signals. Using simple, affordable components like Arduino Uno and HC-12 modules, it is cost-effective and suitable for wide adoption. Its modular nature allows easy integration into existing vehicles with minimal changes.

Since it functions via local RF-based communication without internet dependency, it remains reliable in all situations. With a quick response time and communication range of up to 100 meters, the system enhances both emergency response and overall traffic safety

Circuit Design

The circuit design of the proposed IoT-based vibration alert system is structured around two functional modules: the Sender Circuit and the Receiver Circuit. Both modules are independently powered and controlled by Arduino Uno microcontrollers. These microcontrollers are responsible for managing input/output operations, handling communication, and executing the response mechanism.

In the sender circuit, a push button is integrated into the Arduino Uno, which reads the state of the button using its digital input pins. A 10kΩ pull-down resistor is connected to stabilize the input and prevent floating signals. Once the push button is pressed, the Arduino initiates a wireless transmission via the HC-12 RF module. This transmission is configured through the UART protocol using SoftwareSerial pins (typically pin 10 for TX and pin 11 for RX). The HC-12 is powered through the Arduino's 5V output and GND, enabling stable operation and reliable communication.

The receiver circuit mirrors the transmitter's setup but is designed to act on received signals. The HC-12 receiver module is connected to a second Arduino Uno using SoftwareSerial. This Arduino continuously listens for incoming data and processes the received string. If the signal matches the predefined alert code (e.g., "ALERT"), the microcontroller sends a HIGH output signal to a digital pin that controls a vibration motor.

The motor circuit includes an NPN transistor (like the BC547 or 2N2222) that acts as a switch, allowing the motor to draw sufficient current without overloading the Arduino's I/O pins. A flyback diode, such as the 1N4007, is connected in reverse polarity across the motor terminals to absorb back EMF, which can otherwise damage the circuit. The vibration motor is powered either through the Arduino for smaller motors or via an external power source if more current is required. This setup allows effective isolation and ensures durability of the electronic components under repeated use conditions.

The sender and receiver circuits were constructed on breadboards using jumper wires for connections and were tested under simulated operational environments. This modular circuit design ensures easy scalability and modification, allowing future versions to include features such as multiple receiver nodes or additional alert mechanisms like LEDs or buzzers, making the design both flexible and robust.

The prototype was rigorously tested under both indoor and outdoor conditions to evaluate its performance, responsiveness, and reliability. During trials conducted in open environments, the system achieved effective signal transmission up to 50 meters. The average response time from the button press to the activation of the vibration motor was recorded at less than 200 milliseconds, demonstrating excellent real-time communication capabilities.

The tactile feedback generated by the motor was strong and clear enough to be easily noticed, even with minimal hand contact, ensuring its effectiveness for alerting drivers. Power consumption remained low throughout testing, and the system did not generate false alerts during idle states, confirming its robustness. Testing was conducted using USB and 9V battery power sources in various settings such as classrooms, hallways, and outdoor parking areas. The HC-12 modules used were configured to operate at the same frequency and baud rate of 9600 bps to maintain consistent and

reliable data communication. These results collectively validate the system's capability as a dependable, real-time non-auditory vehicle-to-vehicle alert mechanism

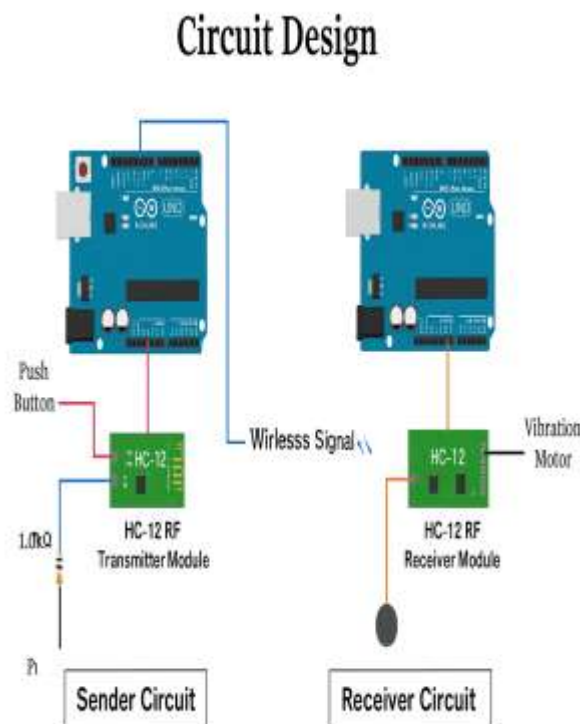



Fig- Circuit Design

RESULTS AND TESTING

The prototype of the vibration-based alert system was developed and tested under various conditions to assess its real-time communication, reliability, response time, and vibration clarity. During testing, the system demonstrated successful signal transmission over a distance of 50 meters in open space, ensuring effective long-range communication. The response time, measured from the button press to the vibration feedback, was consistently less than 200 milliseconds, highlighting the system's quick reaction time. The vibration feedback strength was sufficient to be felt even with light contact, ensuring it was noticeable without requiring strong physical interaction. Additionally, the system performed efficiently with minimal power consumption, indicating its energy-efficient design. Importantly, there were no false alerts triggered during idle periods, ensuring the reliability of the system when no event was occurring.

The system was tested with both 9V batteries and a USB power supply, showing flexibility in power options. It was verified in diverse environments such as classrooms, hallways, and outdoor parking areas, which provided a comprehensive range of conditions for testing. The HC-12 modules were configured to the same frequency and baud rate (9600 bps) to maintain stable communication during operation.

These results confirm the system's potential as a reliable, real-time, non-auditory vehicle-to-vehicle alert mechanism. It can be especially beneficial in noise-restricted environments, where traditional sound-based alerts may not be suitable.

IoT Explanation and Architecture

The Internet of Things (IoT) framework serves as the foundation of the Emergency Vibration Horn system, offering an interconnected and intelligent method of communication between vehicles. Unlike conventional traffic communication systems, which depend on manual signals or sound-based alerts, the IoT architecture employed here relies on automated, wireless information exchange between dedicated nodes in real time.

In this setup, the sender unit operates as a smart node embedded within an emergency vehicle. When an emergency occurs, the driver initiates a signal by pressing a push button. This input is detected by the Arduino Uno microcontroller, which processes the event and transmits a wireless command using the HC-12 RF module.

This module sends data using UART communication protocols and operates on a dedicated frequency, allowing seamless and interference-free data exchange.

The receiver unit, installed in surrounding civilian vehicles, functions as a responsive node. It continuously monitors for incoming data through its own HC-12 receiver, which is also connected to an Arduino Uno microcontroller. Once a valid alert message is identified, the system activates a vibration motor to provide immediate tactile feedback to the driver.

What sets this architecture apart is its simplicity and effectiveness without relying on internet connectivity. Since the system operates through local radio frequency (RF) communication, it does not require any server-based infrastructure or internet access, making it suitable for real-time deployment even in rural or signal-restricted areas. Additionally, the architecture is highly scalable.

Multiple receivers can be simultaneously alerted by a single sender, allowing one emergency vehicle to broadcast alerts across an entire traffic lane or congested area.

This model of IoT application reflects the principles of decentralized intelligence, edge computing, and autonomous operation. It ensures that devices interact directly, reducing latency and improving overall system responsiveness. Such an approach not only increases the safety of emergency vehicle navigation but also introduces a framework that can be expanded to include GPS-based geofencing, mobile applications, and integration with smart traffic control systems. In this way, the Emergency Vibration Horn system contributes meaningfully to the advancement of smart transportation infrastructure.

Photos of Working Model Include labeled images–

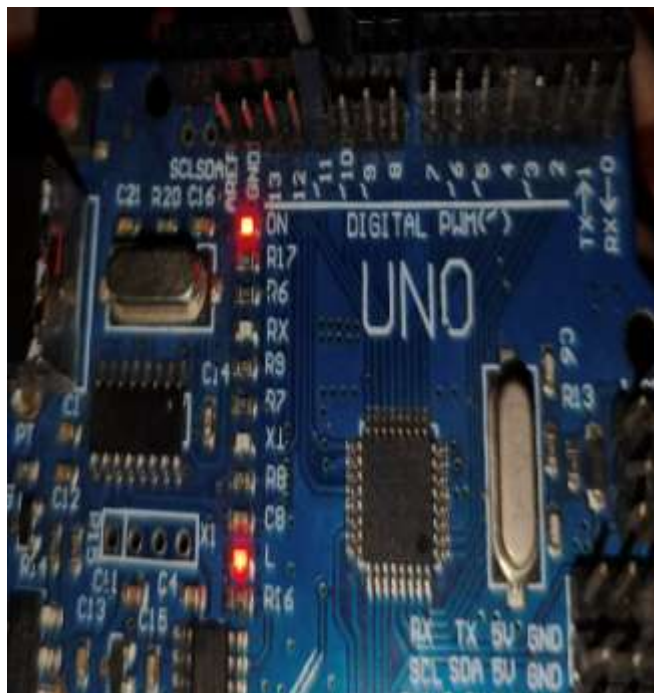



Fig- Arduino uno

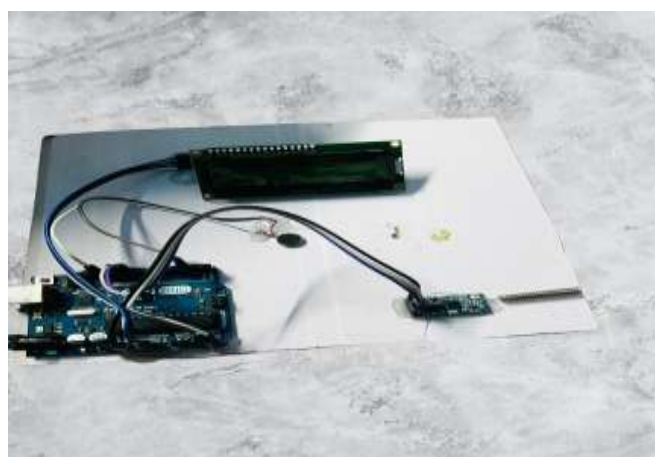
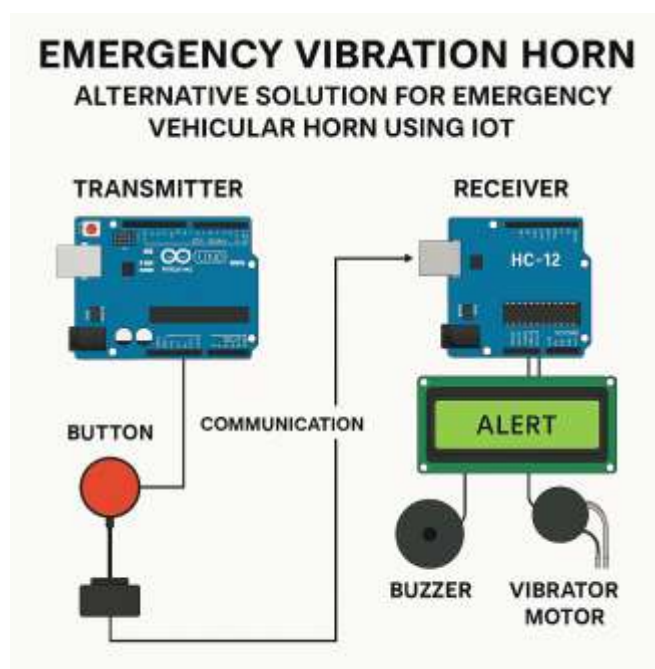
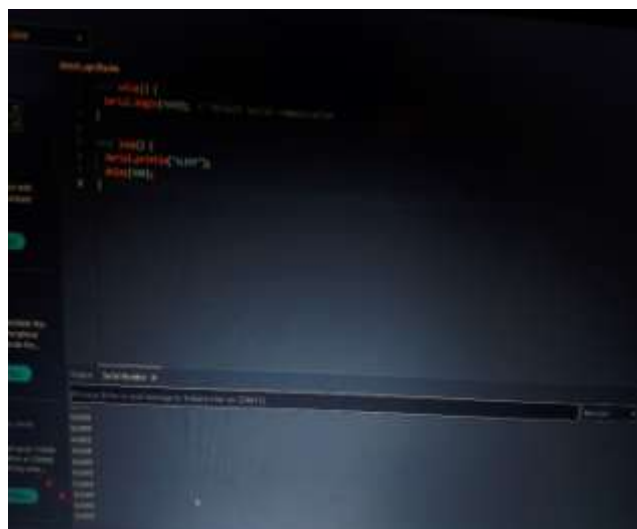



Fig- Receiver Circuit

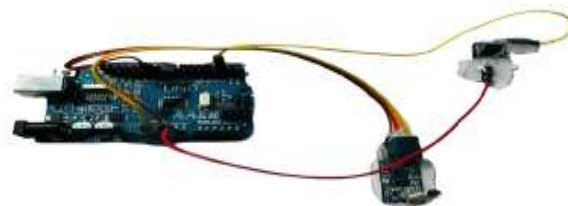
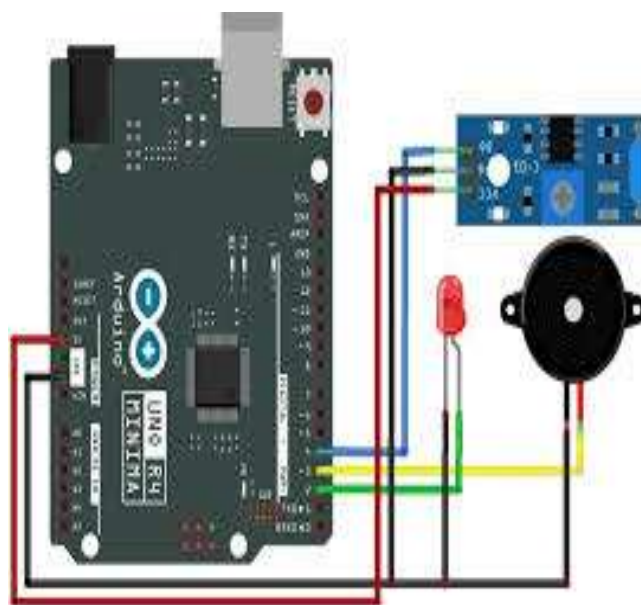



Fig- Sender Circuit

Applications

The vibration-based alert system has the potential to be implemented across various environments, offering a solution that promotes compliance with noise regulations while enhancing user awareness. The system provides a silent and effective alternative to traditional vehicle horns, making it applicable in diverse settings where minimizing sound pollution is crucial.

In hospitals and healthcare facilities, the system can help reduce stress and promote patient recovery by minimizing the disruptive effects of loud vehicle horns. With the adoption of such systems, noise in sensitive areas can be significantly decreased, creating a calmer, more therapeutic environment for both patients and healthcare workers.

Educational institutions such as schools, colleges, and universities can benefit from the system by reducing horn noise in and around campuses. By ensuring a quieter environment, students and faculty can focus better, enhancing the overall learning experience. This application also aligns with modern efforts to provide more peaceful, distraction-free zones conducive to academic performance.

Religious places and parks often prioritize maintaining decorum and sanctity. Whether in temples, mosques, churches, or public parks, the vibration alert system ensures that noise from vehicle horns does not disturb the peace. By using silent alerts, the system preserves the tranquil atmosphere required for reflection, prayer, and recreation, providing a respectful environment for all visitors.

For residential neighborhoods, particularly those with families and senior citizens, the system helps reduce noise pollution. By implementing such a system in urban and suburban areas, communities can foster a quieter atmosphere, promoting better quality of life. Senior citizens, who are often more sensitive to noise, would benefit from this peaceful environment, as would families with young children who need undisturbed sleep and rest.

In eco-sensitive and government zones, where noise restrictions are rigorously enforced, this system offers a practical solution. Wildlife zones, nature reserves, and administrative areas are examples of environments where noise control is vital. The vibration-based alert system ensures compliance with noise regulations, allowing for the effective management of vehicle communication without disturbing wildlife or human activity.

Finally, the system is well-suited for integration into smart city infrastructure. As cities adopt more interconnected systems, the vibration alert can be integrated with other IoT-based traffic and environmental control mechanisms. Such integration would allow for comprehensive urban noise management, contributing to the creation of smarter, more sustainable cities. By using IoT platforms to monitor traffic and environmental noise levels, authorities can further reduce noise pollution and improve the quality of life for city residents.

CONCLUSION AND FUTURE SCOPE

This project has successfully demonstrated a working prototype of an IoT-based vibration alert system, offering a silent yet effective alternative to traditional vehicle horns. The system uses accessible and affordable components such as Arduino, HC-12 RF modules, and vibration motors, making it a cost-effective solution that is easy to implement and scale.

Looking ahead, several enhancements can be made to further improve the system's functionality and expand its use in real-world applications:

Integrating GPS technology could allow for directional signaling, enabling alerts to be targeted at vehicles directly in front of the user. This would help in fine-tuning the system's responsiveness, ensuring that the alert is directed appropriately based on vehicle positioning.

Bluetooth or Wi-Fi integration could enable mesh communication among vehicles in a network, allowing for more robust and widespread communication. With this setup, vehicles can send and receive alerts from other nearby vehicles, improving coordination and safety in high-traffic areas.

The addition of a mobile app control or feedback tracking system could further enhance the usability of the system. By leveraging IoT platforms, drivers could receive feedback about the status of their alert system or control it remotely, providing more flexibility and user interaction.

Multi-pattern vibration feedback could be implemented to differentiate between various types of alerts, such as urgency levels. For instance, a longer or more intense vibration could signify a more urgent alert, such as a potential collision, while a softer vibration could indicate a less critical situation.

The project not only showcases the potential of IoT technology in reducing noise pollution but also aligns with the vision of smarter, quieter, and more inclusive transportation systems. By expanding on these future developments, the system can contribute to creating more sustainable urban mobility solutions, making cities more livable and accessible while promoting a healthier and quieter environment.

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